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ON THE PROBLEMS ASSOCIATED WITH THE ADOPTION OF MODERN SURVEY TECHNIQUES IN THE DEVELOPING COUNTRIES WITH PARTICULAR REFERENCE TO EXPERIENCE IN U.A.R.

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ON THE PROBLEMS ASSOCIATED WITH THE ADOPTION OF MODERN SURVEY TECHNIQUES IN THE DEVELOPING COUNTRIES, WITH PARTICULAR REFERENCE TO EXPERIENCE IN THE UAR

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PREFACE

1. When the present survey of Egypt came into being in 1895 its first task was to push on the cadastral survey in order that the re-assessment of the whole country for land tax might be completed within ten years. This task was so urgent that there was no sufficient time to permit for mapping being delayed until a unified geodetic framework could be established. Discrepencies appeared between the sheets of independently surveyed regions; and the need of a revision of the cadastre was soon felt. The second cadastre was started in 1921 to make new maps at the scale 1/1000 and the new surveys were adjusted to fit into the second order triangulation which had then covered the cultivated regions.

2. The geodetic network across the Nile from Cairo to the frontier of the Sudan Republic was established in the years 1907-1930, and the two branches from Cairo in the NW and NE directions were completed in 1945. Precise levelling commenced in 1906, to establish fundamental bench marks over the cultivated lands to enable the whole of the irrigation system of the Country to be referred to one common datum. Owing to lack of experience much of the work carried out before World War I was not up to the international standard of high precision levelling. A new network was therefore embarked upon and completed in 1936.

3. The economic policy prevailing at that time paid little attention to the desert regions. For military purposes however, a series of topographic sheets at the scale 1/100 000 was started in Sinai and extended to serve as base maps for geological exploration in search of mineral resources by a few foreign companies. To control the plane table work triangulation points of a special class were observed, and the scale was checked by means of measured short bases. The heights were determined from vertical angle measurement.

4. When World War II came to an end, and after fifty years of most creditable toiling, the cadastral survey had covered 40% of the cultivable land, the 1/25000 sheets of the green region were complete but needed revision, and eighty townships had been mapped but many more had no maps and the older sheets were out of date. We also had topographic sheets at the scale 1/100 000 for 40% of the total area of the Country, but some of the sheets were not contoured. The size of the work which remained undone clearly showed that the traditional field methods could not possibly fulfil the normal survey programme of the Country fast

enough to match the post-war pace; and we set to study the possibilities of aerial surveying and electronic distance measurement.

5. It was also clear that the Country was not likely to endure the prevailing political and economic conditions for very long. The great political activities at home culminated in the overthrowing of the old regime and the emergence of the Republic, with new concepts of economic development and social progressiveness, making further heavy demands on the survey establishment for their implementation. The most important were:

(a) The execution of the Agrarian Reform Law (1952) which set an upper limit to the area of individual holding, called for survey operations in scattered areas covering some 500 000 feddans (One feddan equals 4200 square metres or 1.04 acre). Difficulties arose in the areas which had not been reached by the second cadastre, for the areas calculated from the old maps were incorrect in places.

(b) Survey operations extending over 380 kilometres from Aswan to Halfa, for the High Dam hydro-electric scheme.

(c) Land reclamation projects in various places involving the contouring of over 500 000 feddans.

(d) The survey operations required to convert to public property the land required for the construction of irrigation and drainage systems, roads, schools, hospitals and social centres. The projects which necessitated the expropriation of land and the compensation of the proprietors increased from about 200 in the twenties to an average of 650 in the last ten years, reaching the peak value 1228 in the year 1955-1956 shortly before the Suez campaign.

6. When these tasks rushed in, the Survey Department had not the chance to adequately equip itself for the efficient use of modern techniques; and the completion of all these tasks in time was beyond its capabilities. The aerial survey of the High Dam project was therefore carried out abroad. In the meanwhile the number of field parties was increased to meet the heavy demand for 1/2500 contoured maps for the land reclamation projects, and the survey school, which had been temporarily closed, was reopened to train field surveyors. But we never lost sight of the need to modernize the whole survey system to cope with the mapping requirements of the Country. These range from the simplest form of charting the unsurveyed regions to the most detailed and accurate surveys for cadastral sheets, town maps and engineering works in topographically varied regions.

7. As some of the factors which made progress rather slow in the beginning are likely to recur in other countries I propose to treat them in general terms. Examples from experience in UAR will be discussed to show how these difficulties were approached.

FACTORS LIMITING THE USE OF MODERN SURVEY TECHNIQUES IN THE NATIONAL CARTOGRAPHIC UNITS

Capital and foreign currency.

8. Problem No 1 is the cost of the instruments. We must admit that the prices of photogrammetric and electronic measuring instruments are becoming rather prohibitive for the smaller countries. Even the so-called moderately priced units so outstep the imagination of those who are accustomed to budgeting for theodolites, levels and plane-table outfits that it is often an ordeal to persuade them to consider the worthiness of the endeavour to modernize the survey techniques. The situation may be aggravated by the intervention of some veteran of the old school who would argue that, given a few more men and a few more trucks, he would handle the job more economically and just as fast.

9. This problem was partly solved by inducing other government offices to allocate some of the funds available for mapping projects to the purchase of equipment for the Survey Department, thus helping to build up a survey potential which would meet any future demands from them. Shortage of foreign currencies is a serious handicap. We have learnt that we should put up with it and be prepared to do better than insist on specifications which fit only one make.

The level of the local technical potential.

10. The second hindering factor is likely to be the low level of the local technical potential. It is easy enough to train young people with some secondary school education to operate the most modern survey equipment when these are in good working conditions; but it may be difficult to find the person who can locate and adjust the faulty component when the performance of one of these instruments falls below the permissible limit. The fault-finding charts do not solve all the problems; and the attempt to check and repair the instrument may be thwarted by the presence of small differences between the actual construction and the description given in the manual of operation.

11. It is of course true that certain repairs and adjustments must be made in the factory. One may also expect that only the experienced technicians of the makers have sufficient knowledge of the design, construction and expected performance of every component; but we must be aware of the difficulties which we would meet if our production is made to depend, entirely, on equipment the intricacies of which defy the technical abilities available at home.

Organizational difficulties.

12. The adoption of modern survey techniques meets many organizational difficulties arising from the lack of appreciation of the full impact of modern technology on the art of surveying. It must be realized that modernization is not achieved by the mere annexation of a photogrammetric laboratory and the purchase of a few electronic instruments. The whole establishment must be remoulded so that the air survey division embraces all the elements which are necessary for its proper functioning, including the photographic laboratories, the field sections, a computing division, and the drawing offices. Otherwise the activities of the photogrammetrists may be frustrated. It is also noteworthy that instruments

end operators, alone, do not make an efficient survey unit. The true index of productivity is the proficiency of the technical supervisors. These are the most difficult to make an efficient survey unit. The true index of productivity is the proficiency of the technical supervisors. These are the most difficult to make, but they are indispensable.

PROMOTING FACTORS

International cooperation and technical assistance from the more developed regions.

13. The emergent countries naturally look at the United Nations Organization and the highly developed member states for help to overcome these difficulties. In some cases, however, the granted assistance takes the form of financial support to contract mapping projects to specialized commercial companies. This may solve an immediate problem and it may infuse an appreciation of modern survey methods; but it is hardly the way to build up a national experience in surveying and cartography.

14. Joint projects in which personnel from the recipient country take an active part are of greater value to the long-term technological development. An interesting example from a related field is the soil survey project which is still in progress in the UAR. The agreement with FAO allowed for both

(a) the employment of technical experts to help conduct the operations and to train Arab agriculturists, and

(b) scholarships to study the subject abroad.

Similar arrangements would help establish national cartographic units, but the take-over must be intelligently planned, in order that the lively establishment may not degenerate into lonely instruments in closed rooms after the visiting experts leave for home.

15. To my mind, a very effective way in which the international organizations can help promote the application of modern survey techniques for the benefit of the developing countries is to establish regional training and research institutes. These will at once solve the problem of training recruits from the neighbouring countries and help to tackle the local problems which crop up in the course of production.

The development of adaptable simplified techniques.

16. Under the conditions prevailing in most of the emergent countries, an appraisal of the possibilities of the simple methods of surveying from aerial photographs is opportune. The problem of transferring the topographical features from the aerial picture to the base map has a number of satisfactory solutions employing simple tools such as the sketchmaster, single projectors, and the plotting devices that are based on the radial line method. The slotted template method serves for the control of the scale.

17. The development of a photogrammetric method of height determination and contouring by means of simple instruments is fundamentally more difficult, because of the greater practical significance of height errors. Several graphical and numerical methods were proposed for the computation of appropriate heights from parallax measurement; and a few plotting devices were designed to

mechanize the approximate analytic solutions. But the impression of the word 'approximate' and the showers of pamphlets written in praise of the stereoplotting instruments based on the 'exact' geometrical principles kept the attention so fixated on these machines that many photogrammetrists believed that nothing else was worth a place in a modern air survey department.

18. A few years ago the representative of an oil company prospecting in UAR called for advice on the solution of an urgent problem in the western desert. Rather prcise elevations were required, but there was neither the time to determine them in the field nor the inclination to bring in suitable plotting machines. We therefore set to look into the possibility of improving upon the known methods of determining height from parallax measurement. A more rigorous derivation of the functional relationship between height, the parallax and the photographic coordinates led to the development of a simplified method that gave approximately H/6000 for the root mean square error of height determination, H being the flying altitude.

19. To ascertain the theoretical expectations of the method and to clear the ground for further developments the general theory of therepresentation of model deformations by polynomials in the photographic coordinates in any type of terrain was elaborated in a paper published in 1958. The goodness of the representation can be maintained in mountainous regions by means of a simple numerical device. The observational routine is very simple, and the complete set of stereoscope and stereometer is worth qbout £ 80. The calculations need no advanced educational equipment, and the work can be subdivided so that a man can be quickly taught his part. At the same time the method permit of efficient checking and control of production.

20. The utility of the simplified techniques is greatly enhanced by the recent advances in the gyroscopic stabilization of the air camera mounting. Experience in UAR shows that the gyroscopic stabilization keeps the tilts well within one degree. The maximum error due to the replacement of the exact solution of the problem of height determination by the improved approximation to which I alluded is in the order of H/10 000 when each of the tip and the tilt is one degree. This high order of the intrinsic precision makes the 'exactness' of the geometrical solution superfluous but for the most exacting jobs. The additional cost of gyroscopic stabilization is outweighed by the possible simplification of the mapping procedure. The equipment seems, however, to be of a rather delicate balance and needs expert handling. This does not affect its adaptability for use in the developing countries who contract experienced air survey companies to undertake the aerial photography. The proper functioning of all the airborne equipment is in this case the responsibility of the contractors.

21. Good use of the simple methods accomplishes many survey tasks at minimum capital expenditure and evades the difficulties mentioned earlier in this paper. The simple methods help to make a successful start, and give good experience to the young photogrammetrist. At the same time they relieve the stereoplotting machines to the jobs which can not te done otherwise. In the photogrammetric laboratory of the Survey of Egypt we have a team of ob-

servers and computers mapping some 2000 000 feddans for the soil survey project and another team working on the revision of 1/25000 sheets.

PLANNING AND COORDINATION OF SURVEY WORK

22. I shall wind up by submitting a few remarks bearing on the organization of cartographic units and the planning and coordination of survey work:

(a) We have seen that the simple methods of surveying from aerial photographs are most useful when the quality of the photography is best. The combination of good photography and the simple techniques of mapping from it is so potent that the question of securing a reliable source of supply should top all the questions pertaining to the planning of survey work. The recent advances in navigational aids, camera stabilizationm high-resolution distortion-free wide-angle lenses and improved films help to produce the type of photography from which maps can easily be made, and which are most useful for photo interpretation.

(b) Each country will sooner or later find it advisable to have its own survey aircraft. Until then, aerial photography may be entrusted to a reputable air survey company on contract basis. The specifications must be unambiguous and adequate, but the tendency to make them too tight must be checked, first because it puts the prices up and, secondly, because the advisors of the contractors will not fail to find a loophole in a lengthy contract if the rejections are not practically justified. Both parties may be saved unnecessary inconvenience if the contract stipulates the tests and the sampling techniques which will be used to check the quality of the supplied materials.

23. The question of the precision of the maps required for the planning of development schemes needs careful consideration, for there is sometimes a tendency to take for granted the standard of regular mapping, thus making the job costly and time consuming.

24. We recently broke through an interesting example of 'precision barrier'. Our town planners wanted maps at the scale 1/1000 for the larger villages as part of the five-year development scheme. Considerations of time and cost ruled out the use of the standard field methods, and the task would have been impossible to accomplish in time even by photogrammetric methods if the criterion of plottable error were to be upheld at this scale. We therefore made a sample map at the required scale from the photographs previously taken for an experimental crop survey project at the scale 1/10 000. The surrounding fields were plotted from the photographs, and the un-identifiable boundaries were transferred from the available cadastral sheets which were also used to control the scale of the models in the steroplotting machines. The map was carefully examined by the town planners and found to meet their requirements. The project is now advancing satisfactorily at the rate of 17 villages a year per machine working one shift. Each map carries a brief description of the method of production.

25. Where ground control is sparse the slotted template method is still the simplest and most efficient means to control the scale of the models in a block of photographs, particularly if the camera was gyroscopically stabilized. The stereotemplates solve the same problem in mountainous regions.

26. The general problem of height control has no such elegant solution as yet, in spite of the large number of publications on aerial triangulation and block adjustment. Until a revelation of genius solves this problem we have to make the best use of the available ground control to reduce the costly field operations. In certain desert regions of UAR the existing triangulation is dense enough to control the individual models if the photographs are taken from high altitude. Or one occasion we analytically treated the photographs which had been taken from 30 000 feet to obtain control for the lower altitude photography which used for the mapping. The triangulation points were, in the most part, easy to locate on the high altitude photography. To reduce the possibility of errors of point transfer from one picture to the other we observed groups of neighbouring points instead of single points. This also increased the precision. Small-block adjustment solved the problem of height control on another occasion.

27. Modern optical-electronic methods of distance measurement are under experimental studies in UAR to become familiar with their intricacies, and to define their proper scope of application. We also feel that the logistics of field work need revision. Trucks are still used where light aircraft and helicopters would save valuable time.

28. Many years ago the founders of the Survey of Egypt realized that one of the essentials to improvement of the quality of the work was that the computation should be taken out of the hands of the observers and entrusted to a central staff under skilled mathematicians. This rule is observed in most survey establishments, but the responsibilities of the mathematical services have increased by the introduction of modern survey techniques. It would therefore be a miscalculation to start a national survey to-day with no mathematician within call. His duty will include the systematization of the computing. He will fix the standard of precision in the observation and the computation; and will develop and apply a careful system of quality control. Recent researches in the application of mathematical statistics to the analysis of errors in survey work and to the design of experimental studies in this field show that a good background in this subject is a great advantage. It helps us to read the specifications and instrument-performance data more intelligently, to detect flaws due to defective instruments and the indiscretion of an observer or operator; and it teaches us how to design tests and economic experiments to decide the value of suggested improvements.

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